

Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 806 536 A1

(12)

# EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:

12.11.1997 Bulletin 1997/46

(21) Application number: 96900326.8

(22) Date of filing: 17.01.1996

(51) Int. Cl.<sup>6</sup>: E05F 15/10, H01H 47/00

(86) International application number:

PCT/ES96/00006

(87) International publication number:

WO 97/13949 (17.04.1997 Gazette 1997/17)

(84) Designated Contracting States:

AT DE FR GB IT NL

(30) Priority: 11.10.1995 ES 9501964

(71) Applicant:

Falveley Espanola, S.A.  
43080 Tarragona (ES)

(72) Inventor:

BOJ CABISTAN, Victor Juan  
E-43080 Tarragona (ES)

(74) Representative:

Carpintero Lopez, Francisco  
HERRERO & ASOCIADOS, S.L.  
Alcalá, 21  
28014 Madrid (ES)

## (54) CONTROL SYSTEM FOR AUTOMATIC DOORS

(57) A safety system the structure of which is based on a microcontroller (1) which carries out readings of the orders to open (LA) and to close (LC), (together with the speed (V) of the vehicle), a relay for the order to close (2) governed by a transistor (5), and a relay for opening (3) governed by a transistor (6), these two relays and their transistors (5) and (6) being powered by another transistor (7). The system carries out periodical supervision thanks to clock signals generated by the microcontroller (1) of the state of the switching transis-

tors, checking that the orders given are definitive and coincide with the action that has been brought about, entering if this is not the case into a routine of internal stoppage of the microcontroller (1), shutting off motor traction, and bringing the relay contacts into a safe position which prevents the untimely opening of an automatic door. In the case of a fault arising in the microcontroller the relays are deactivated.

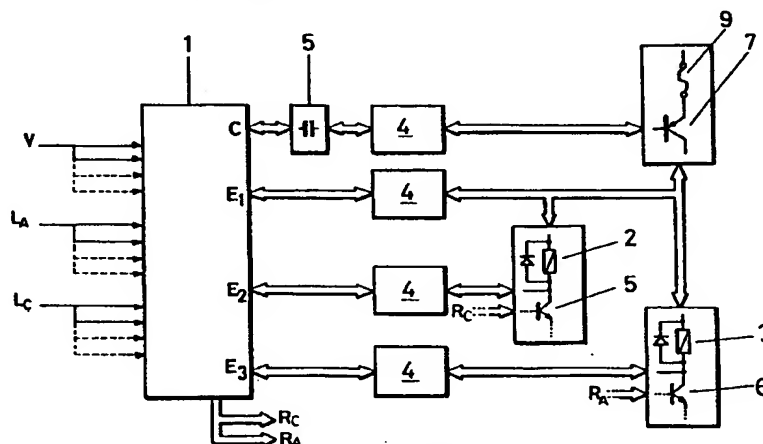


FIG.-1

## Description

## OBJECT OF THE INVENTION

5 This invention refers to a safe control system with a single microcontroller, which has been especially designed for automatic doors, such as those used in railway carriages, in which safety at the moment of giving the order to open the doors has to be absolute, given the logical effects of this action on the physical integrity of travellers.

The object of the invention is to establish a safety system for opening doors, which is as safe or safer than a classical logic system using relays, and which is also capable of intelligently controlling the movement of contacts, ensuring  
10 that this only takes place at the correct times.

## THE BACKGROUND OF THE INVENTION

15 Traditionally in the world of rail passenger transport, as well as in other areas in which similar performance is required, two or three main variables are taken into account in governing the opening of carriage doors: one line for opening the doors (LA); another line for closing them (LC) and in some cases, the speed (V) of the vehicle to act in a redundant fashion to the order for closure (LC).

These variables directly affect certain relays which determine the direction in which the motor turns, and which with their relevant interlocks, authorise or prevent the opening of the doors when the order is stable, i.e., if for example on  
20 the basis of a situation of rest in which line LA is deactivated, line LC is activated and speed is high, another situation arises in which line LA is activated, line LC is deactivated and speed is zero or low, then the doors are opened, this consisting in practice of what is commonly known as direct control.

These classical methods for door control attain a high level of safety, thanks to the above - mentioned interlocks, given that if starting out from the same position of rest, if due to any reason the opening line connects with positive, line  
25 LC will also remain positive and if speed is also high, then this does not give rise to the conditions needed for the doors to be opened, i.e., the system acts with two logical steps (LA, LC) or three (LA, LC, V).

Likewise, these systems for direct control present an additional problem, and this is that the contacts of the relays move when the order changes, without taking into account the current which is moving across the contacts, with opening-closing-opening manoeuvres which are highly continuous, such as those arising in a station when the operator of  
30 the train opens and closes the doors repeatedly for the late entry of passengers, the contacts may become burnt, given that the inductive charge which they have to cut for the purposes of this manoeuvre is quite large, i.e., the corresponding and well - known spark is produced at the contacts. Timers are used to solve this problem, based on condensers in parallel to the relays, although nevertheless these timers are not an optimum solution due to several different reasons, given that the condensers may dry out, and may suffer variations in their capacity over time, as well as that manoeuvres  
35 or counter-manoevres may take place more quickly or more slowly, etc. ...

Another method for manoeuvres of this type is to use a microcontroller, which makes use of practically the same variables to decide when the conditions are correct for the activation of the opening relay or the activation of the closing relay in an intelligent way, so that movement of the relay always occurs without the presence of current in the contacts and in the shortest possible time.

40 This method, which during normal working offers advantages arising from the intelligent control of the relays, nevertheless presents a highly delicate problem in terms of safety, and this consists of the high dependence of the system on a single component, i.e., that in case of a fault arising in the microcontroller an unforeseen and ill-timed situation in the relays, which may definitively give rise to the opening of the doors at the wrong time.

Given this possibility, redundant systems tend to be used in practice, with 2, 3 or more microcontrollers, thereby  
45 attaining the degree of safety that is necessary for this operation, although with the drawback that the cost is notably increased by this solution, as well as its size, due to the inclusion of more than one microcontroller.

## DESCRIPTION OF THE INVENTION

50 The control system for automatic doors proposed by this invention has been designed to resolve in a fully satisfactory way the problems described above, thanks to which it is possible to undertake the manoeuvre of opening or closing the doors with a high degree of safety, while also simultaneously preventing the burning of the relay contacts involved in opening and closing.

To this end, and more specifically, the control system proposed by the invention is fundamentally based on a single  
55 microcontroller, which by making use of internal automatic controls reads the said variables in three or more successive instants for each one, and using at least two different routes for each, and by the generation of complex and dynamic signals at such a frequency that relays are excited, acts to prevent the untimely opening of doors, as if the system used three or more microcontrollers, in terms of time rather than space.

This brief introduction alone makes it possible to clearly appreciate one of the main advantages deriving from the

usage of this system, i.e., that the introduction of this system gives rise to considerable savings in economic terms, from the viewpoint of the development and manufacture of the final design of the system for controlling doors, as well as a prolongation of the useful life of the relays.

Functionally, the system consists of a microcontroller with three or more inputs for the variables governing the orders to close and speed, as well as three or more other inputs to receive information on the state of the transistor used to supply the relays, and the state of the two transistors governing the relays.

Likewise, the microcontroller supplies a signal at a frequency that is linked to the internal timer and the supervisor (watchdog) of the microcontroller, and through a condenser, which is no more than a clock signal which goes on to be used to set the sequence which the system is to follow in its checking phase, and which is only to be present if the state of the supervisor (watchdog) is at one and all of the controls for checks carried out by the microcontroller are correct.

The system is structured in such a way that the microcontroller receives on the one hand the variables pertaining to the system, i.e. the lines of the orders to open (LA) or to close (LC) (as well as the signal indicating speed), so that by making use of the high performance of this type of electronic device, each of the readings of the said system variables is repeated two, three or more times, using different ports or by the same port but in a different form, i.e., changing the declaration of the port in question so that it may use direct input, input with a digital analogue converter, etc.... all this depending on the microcontroller which is used and the ports with which it is equipped.

Physically, this phase of the reading of each one of the variables corresponding to system orders may be undertaken by the input of the microcontroller itself, although internally reading is not carried out by the same circuits, that is the same value of a reading runs internally along different routes. These readings are then stored in an appropriate way in different microcontroller records.

The relays (RA or RC) are powered by chopped direct current, in such a way that there is always a frequency component passing through a condenser to activate the relays.

On the other hand, as well as the readings of the orders which have already been remarked, the microcontroller data on the state of the relay power transistor through the corresponding adaptation stages, as well as the state of the two transistors which command their respective relays, in such a way that the good working (cutting, conducting) of each transistor is continually verified.

The microcontroller checks that the data of a sequence previously stored in its memory coincide with the sequence which it receives through its inputs E1, E2 and E3, corresponding to the state of the transistor powering the relays, and that of the transistors governing the said relays. In the case that the orders of the microcontroller do not coincide with the readings taken, then it will automatically stop the motor by inhibiting the chopper through the inhibition / activation line (CE) while switching the speed order line to the motor (VM) to zero, and then immediately declaring a reset situation and returning to the initial state of the system.

In the same way, if one of the transistors suffers a short circuit during the checking sequence, and therefore does not coincide with the orders of the microcontroller, a special stoppage routine is then initiated, which stops the motor activating the doors if this is in traction mode, given that a complete reset of the system would burn out the contacts.

Definitively, the system checks that every order given is obeyed in correct fashion, in such a way that if a fault arises in the microcontroller then it is practically impossible for the signals necessary for the relays to be excited to be generated, while if two transistors (5, 7, or 6, 7) suffer a fault simultaneously then motor traction is inhibited by the microcontroller through the cutting of the chopper (CE) and the reduction to zero of the motor speed order (VM). Likewise, the unchopped current circulating through the relays will increase the intensity consumed by their windings and give rise to the activation of the overcurrent protection (9).

## DESCRIPTION OF THE DRAWINGS

To complement this description and with the aim of helping towards better comprehension of the characteristics of the invention, this descriptive report is accompanied, as an integral part of the same, by a set of drawings in which, as illustrations and not limitations, the following are shown:

Figure 1.- Shows a diagrammatic representation of the control system for automatic doors constructed in agreement with the subject of this invention.

Figure 2.- Shows a diagrammatic representation of an oscillogram in which as an example the changes of state occurring in the signals involved in the system are shown, during a checking sequence in the case of the activation of the opening relay (RA), and in which discontinuous vertical lines appear, corresponding to the instants at which the microcontroller takes readings.

## PREFERENTIAL EMBODIMENT OF THE INVENTION

In the light of these figures, and more specifically figure 1, it may be seen how the proposed control system is structured on the basis of a microcontroller (1), which takes readings of orders to open (LA) and to close (LC) as well as the

speed (V) of the moving vehicle, either through different input ports or in different forms through the same port. That is, the declaration of the port through which readings are taken is changed, so that it may be direct input, or through an analogue - digital converter, etc...

Each manoeuvre relay is governed by a switching component, preferentially two pole transistors, i.e., the closure relay (2) is governed by the action of the transistor (5) while the relay for opening (3) is governed by the transistor (6), these two transistors (5) and (6) being powered by another transistor (7) with its corresponding overload protection (9) in series.

The reading of the state of the power transistor (7), the closure relay transistor (5) and the opening relay transistor (6) is undertaken through the corresponding stages of adaptation (4), by means of inputs E1, E2 and E3 of another of the microcontroller (1) ports.

The microcontroller (1) generates a signal C at a frequency linked to the internal timer and supervisor (watchdog) of the microcontroller (1) through a condenser (8). This is the clock signal which determines the sequence followed by the system in its checking phase, and which is only to be present if the state of the supervisor (watchdog) and the verifications are correct.

Definitively, by means of this system, as well as increasing safety to a great extent, is also able to eliminate the classic effects of sparking at the control relay contacts, which over the long term has a positive effect on the working performance of the system, given that it permits the said contacts to be used for longer periods of time, as it lengthens their useful lives.

The system which is the subject of this invention is explained below, with the aid of the following example, which is offered as an illustration of the invention and should not be considered to limit the scope of the same.

### EXAMPLE

This example illustrates the working of the system which is the subject of this invention with the aid of the oscillogram shown in figure 2.

As may be seen, in the absence of the order to open, when the clock signal generated by the microcontroller at output C switches to a logic or high level signal, the three points of reading, which correspond to the state of the power transistor for the relay (7) transistors, which (5) and (6) are also at a high level.

At the moment of giving the order to open to the transistor (6), this transistor switches to conduction (saturation) so that it passes the signal E3 to low level. Instants afterwards, when the order to open relay has been given and the clock signal passes to low level, the other two signals representing the state of the transistors switch to zero, i.e., the transistors (5) and (6) switch to shut - off.

All of these orders are received automatically by the microcontroller (1) through the level adaptor stages (4) and it compares them with the sequence which it stored beforehand in memory of the prior readings.

The following table showing Safety mechanisms describes the effect (with the cause of the effect in brackets) which is brought about in the case of a fault arising in any of the basic control elements of the system.

FAULT	EFFECT	OPENING
1 Tr	Stoppage of the motor ( $\mu$ C) + Drop of the relays ( $\mu$ C)	IMPOSSIBLE
2 or 3 Tr's	Stoppage of the motor ( $\mu$ C) + Drop of the relays (9)	IMPOSSIBLE
$\mu$ C	Stoppage of the motor + drop of relays (absence of signals at suitable frequency)	IMPOSSIBLE

It is not thought necessary to make this description any longer, as any expert in this field will understand the scope of this invention and the advantages which it offers.

The materials, form, size and distribution of the elements are subject to variation, always on condition that this does not give rise to any alteration to the essential nature of the characteristics of the invention.

The terms in which this descriptive report has been drawn up are always to be understood in broad and not a limiting sense.

### Claims

1. A safe control system for automatic doors, essentially characterised in that its structure is based on a microcontroller (1) which undertakes readings of orders to open (LA), and to close (LC), and optionally also of the speed (V) of the vehicle, a relay for the order to close (2) preferentially governed by the action of a transistor (5) and a relay for opening (3) preferentially governed by a transistor (6), these two transistors (5) and (6) being powered by another

transistor (7) with its corresponding overcurrent protection (9) in series.

2. A safe control system for automatic doors, according to claim 1, characterised in that the readings of the state of the power transistor (7), the closure relay transistor (5) and the opening relay transistor (6) are carried out through their corresponding adaptation stages (4), by means of the corresponding inputs of another one of the ports with which the microcontroller (1) is equipped.
3. A safe control system for automatic doors, according to the above claims, characterised in that the microcontroller (1) generates signals C, RA, RC, in frequency over the relays, linked to the internal timer and supervisor (watchdog) of the microcontroller (1) and through condensers (8), which set the sequence followed by the system in its checking phase ( $t_1$ ,  $t_1$ ,  $t_3$ ).
4. A safe control system for automatic doors, according to claim 1, characterised in that each reading taken by the microcontroller (1) is carried out either through different input ports or by the same port although in different modes, changing the declaration of the port inputs, so that when inside these readings follow different routes.
5. A safe control system for automatic doors, according to the above claims, characterised in that in the case of faults arising simultaneously in transistors (5, 7) or (6, 7) it is impossible to maintain excitation of the relays with unchopped current in a suitable cyclic ratio, given that pure direct current causes the current in the winding of the relay to increase excessively, and gives rise to the activation of the overcurrent protection (9).
6. A safe control system for automatic doors, according to the above claims, characterised in that the microcontroller (1) continually verifies the correct working of the accumulator, the internal signals (flags) and the logical operations involved in comparison, as a prior condition for the comparison of the several reading of input variables, bringing about a reset situation in case of fault.

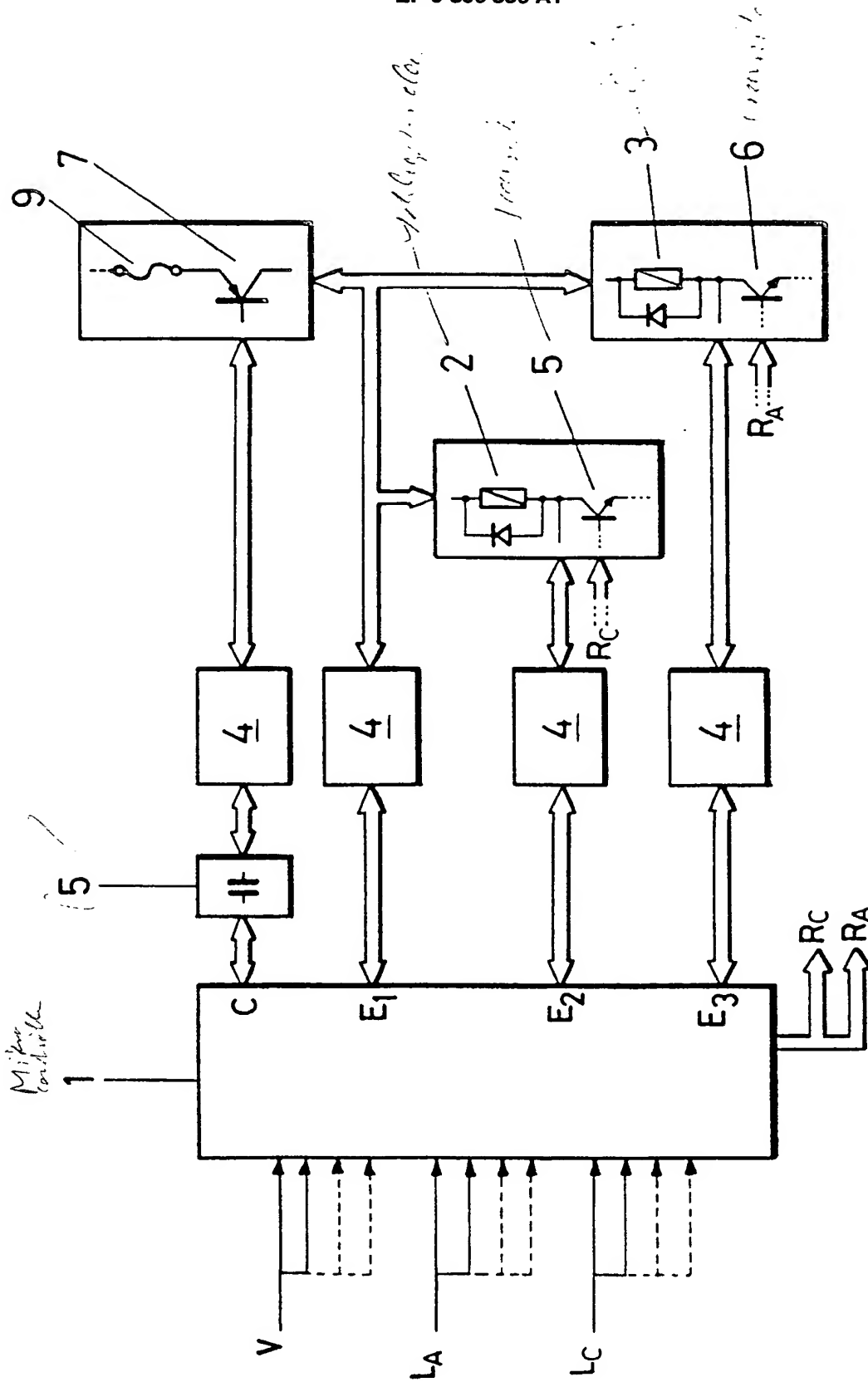


FIG.-1

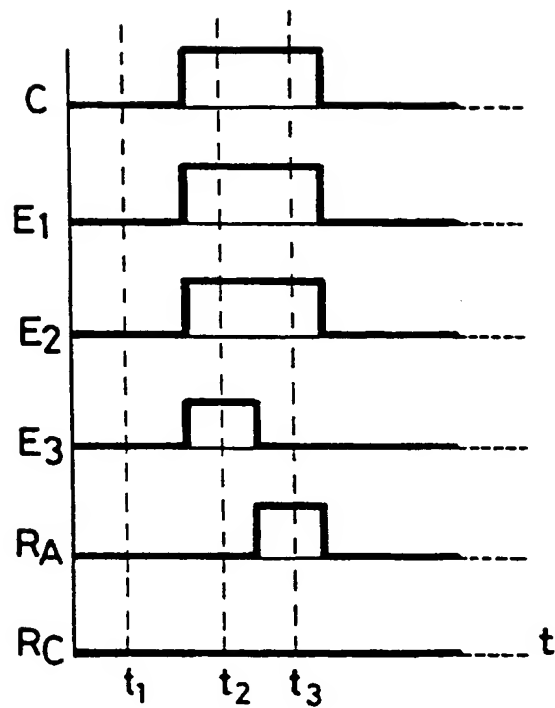


FIG.-2

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES 96/00006

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: E05F 15/10, H01H 47/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01H E05F H03K H01F G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0625625 A (GEN MOTORS CORP), 23 November 1994 (23.11.94) See column 7, line 25 - column 8, line 23, figure 6	1
A	PATENT ABSTRACTS OF JAPAN Vol. 012, no. 400 (M-756), 24 October 1988 (24.10.88) Y JP 63144704 A (RAILWAY TECHNICAL RES INST; OTHERS:02) 16 June 1988 (16.06.88), see abstract	1,2
A	GB 2181613 A (ML AVIATION CO LTD), 23 April 1987 (23.04.87) See abstract; figure 1	1,5
A	DE 4340715 C (DORMA GMBH Y CO KG), 30 March 1995 (30.03.95) See claims; figure 1	1,3

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

24 April 1996 (24.04.96)

Date of mailing of the international search report

30 April 1996 (30.04.96)

Name and mailing address of the ISA/

Authorized officer

Facsimile No. S.P.T.O.

Telephone No.



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES 96/00006

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5321343 A (KANE JR JOHN W ET AL), 14 June 1994 (14.06.94) See column 1, line 61 - column 2, line 34	1,4
A	WO 9318444 A (DORMA GMBH Y CO KG), 16 September 1993 (16.09.93) See page 15, line 15 - line 32; figure 3	1,6
A	GB 2081927 A (MATSUSHITA ELECTRIC WORKS LTD), 24 February 1982 (24.02.82)	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

**THIS PAGE BLANK (USPTO)**